U.S. Technology & Compliance Outlook

11th International CTI Symposium, May 2017, USA

- Casey Selecman, IHS Markit; Greg Pannone, Novation Analytics -

U.S. Transmission Market Overview

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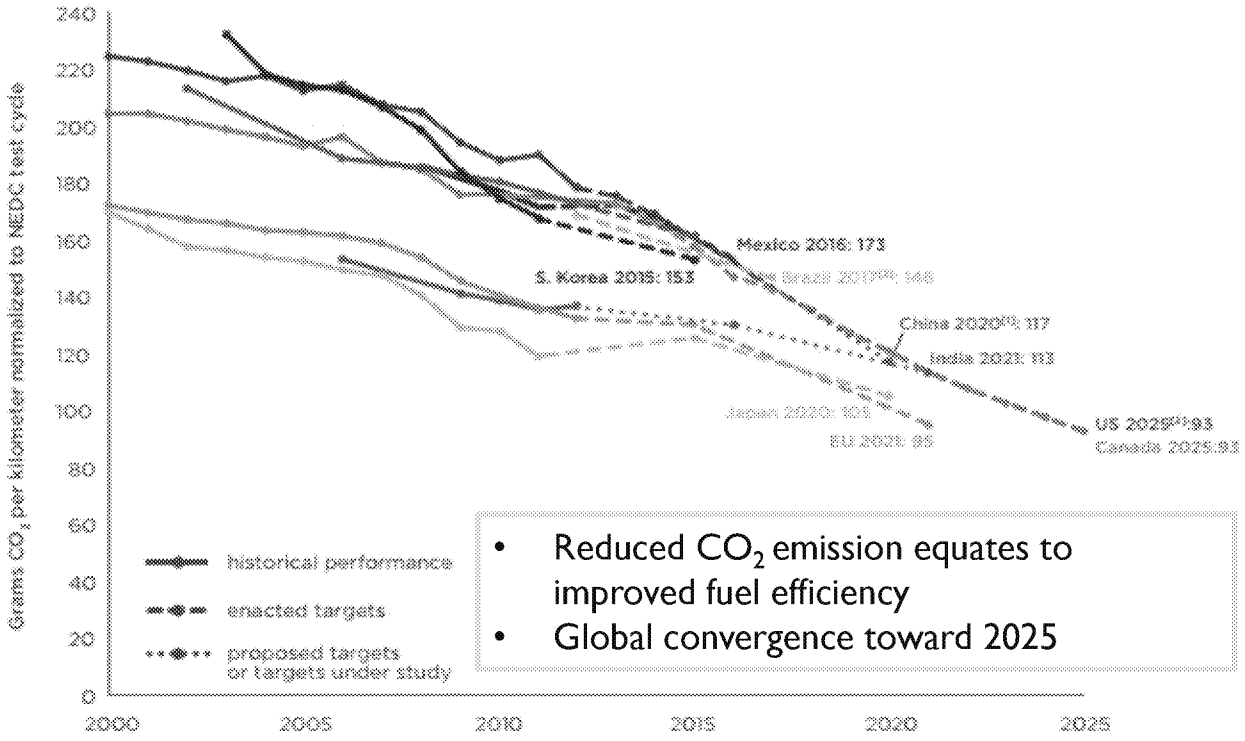
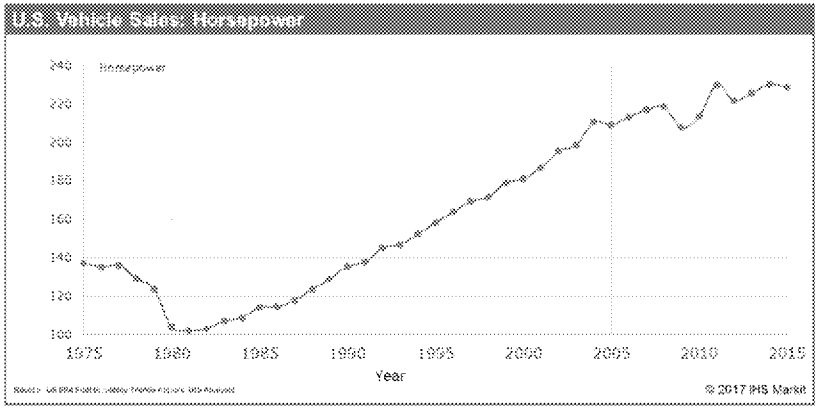
Global CO_2 Targets Driving Technology Evolution



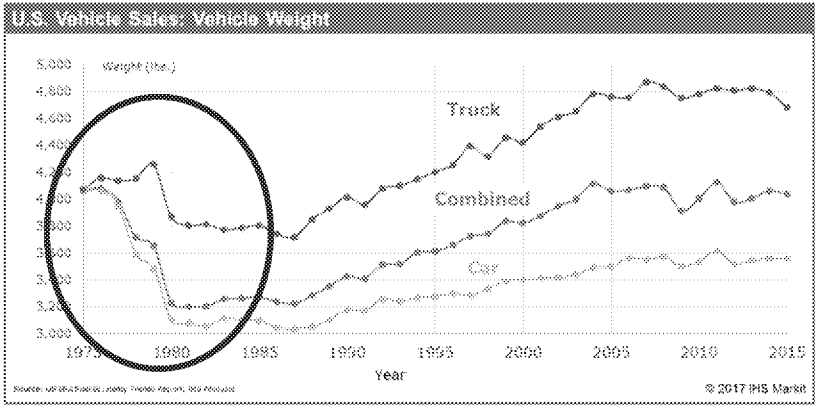
Source: ICCT

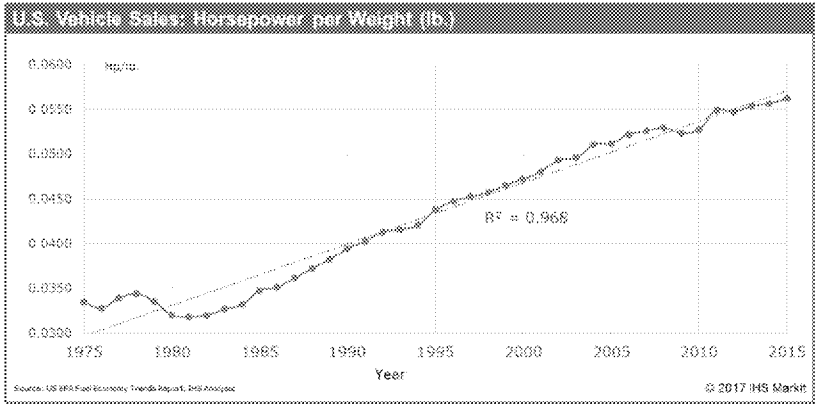
- The global standards for Fuel Economy and CO_2 are converging
- Additional technology will need to be adopted globally to meet these very strict goals
- Automatic shifting transmissions play an additional role in the future as many new technologies (autonomy) will rely on the vehicle to shift itself

Market driven results from CAFE regulation and fuel prices:

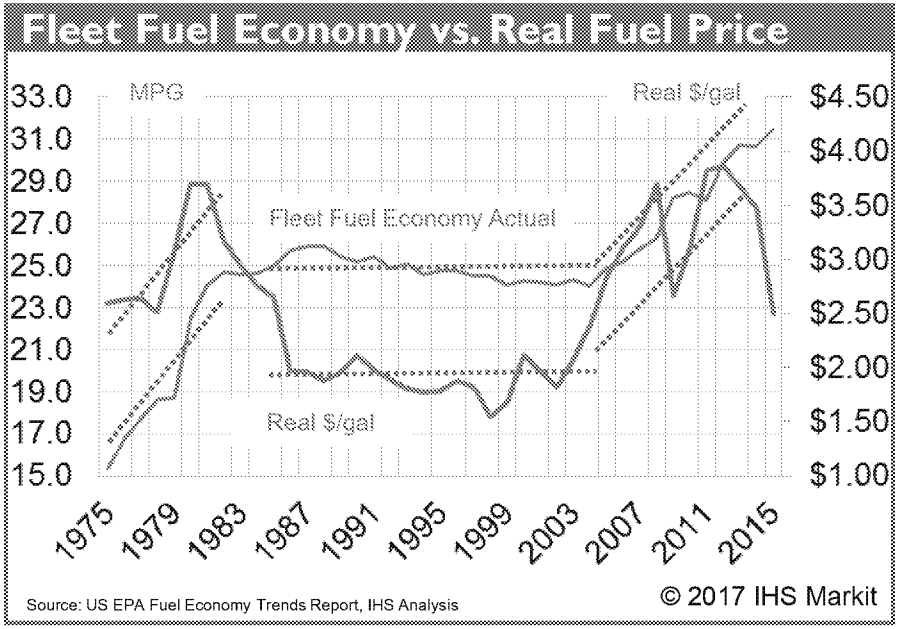


- Massive shift in vehicle choices driven by fuel shortage and CAFE
- Consumers still demand ever increasing performance in their vehicles
- Increasing demand for torque capacity or weight reduction to preserve trend?





Historically, U.S. consumers have been heavily influenced by the price of fuel.



- Shortages and fuel lines led to external demand for vehicles with high MPG
- Birth of the Sport Utility Vehicle!
  - Growth in CUV/SUVs from truck CAFE freeze in 1996 to today is ~4.5M vehicles/yr.
- Recent shift back to FE growth: 2008 economic crisis and fuel price spike
  - 1975 trend? Or 1985 trend?

OEMs can't get the market to purchase high fuel economy vehicles while fuel prices are low, but performance/utility is always demanded.

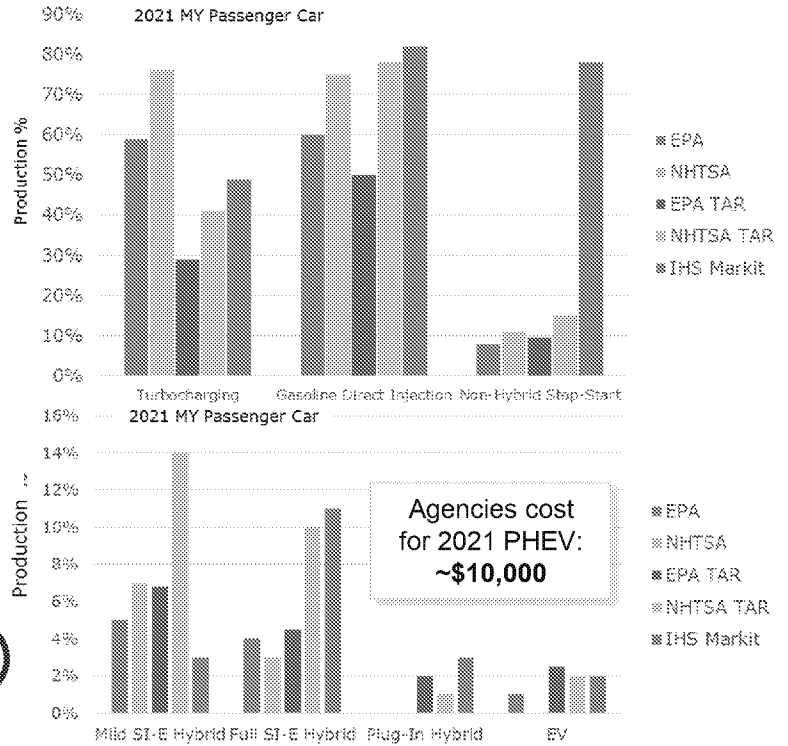
The Agencies assume ~$2,500 in cost to comply with 2025 regulation but IHS technology forecasting differs.

- The Final Regulatory Impact Assessment (FRIA) for 2012-16 and 2017-25 indicate a cost to comply for the industry at:
  - $907 for the '12-'16 regulation
  - $1,361-$1,577 for the '17-'25 regulation

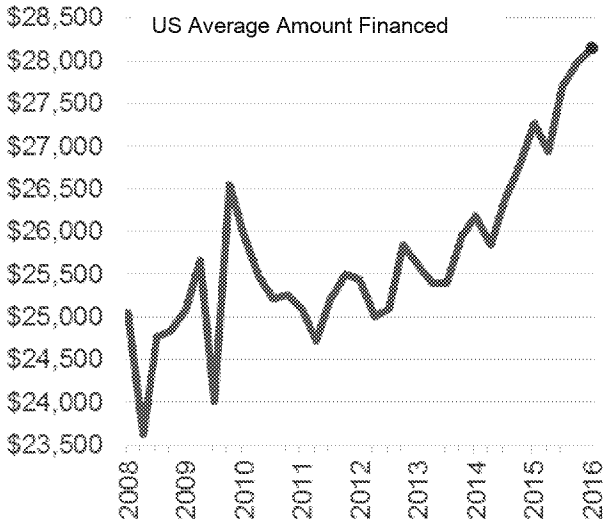
Table V-150 Penetration Rate of New Technologies to Passenger Cars, by Baseline Model Year and Alternative.

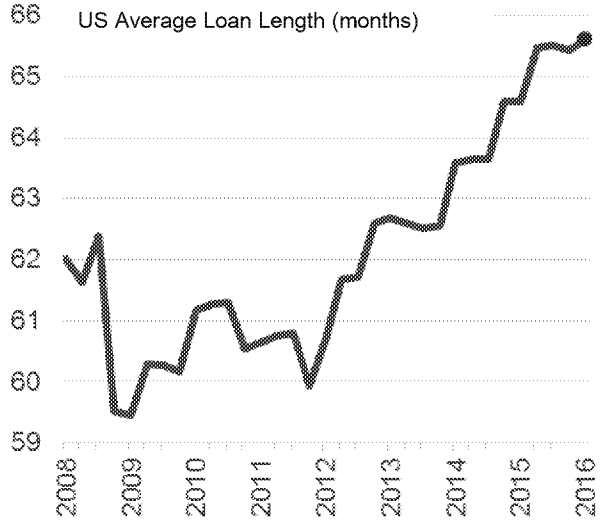
Preferred Alternative - Passenger Cars - 2008 Baseline										
Technology	Abbr.	MY 2017	MY 2018	MY 2019	MY 2020	MY 2021	MY 2022	MY 2023	MY 2024	MY 2025
12V Micro-Hybrid (Stop-Start)	MHEV	6%	6%	9%	12%	14%	14%	15%	13%	12%
Integrated Starter Generator	ISG	1%	2%	2%	7%	7%	10%	11%	17%	24%
Strong Hybrid - Level 1	SHEV1	3%	3%	3%	3%	3%	3%	3%	2%	2%
Conversion from SHEV1 to SHEV2	SHEV1_2	0%	0%	0%	0%	0%	0%	0%	1%	1%
Strong Hybrid - Level 2	SHEV2	0%	0%	0%	0%	0%	0%	0%	0%	1%
Plug-in Hybrid - 30 mi range	PHEV1	0%	0%	0%	0%	0%	0%	0%	0%	0%
Plug-in Hybrid	PHEV2	0%	0%	0%	0%	0%	0%	0%	0%	0%
Electric Vehicle (Early Adopter) - 75 mile range	EV1	0%	0%	0%	0%	0%	0%	0%	1%	2%

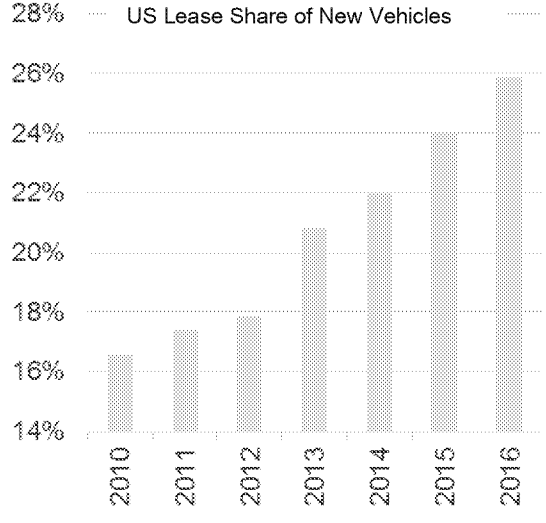
Source: 2012-2016 FRIA, 2017-2025 FRIA



The effects of GHG/CAFE regulations are already impacting customers…







Since the release of the final rules on GHG and CO_2, the average new vehicle price is up >10%: ADAS, electrification, and consumer technology cost still have not been full realized.

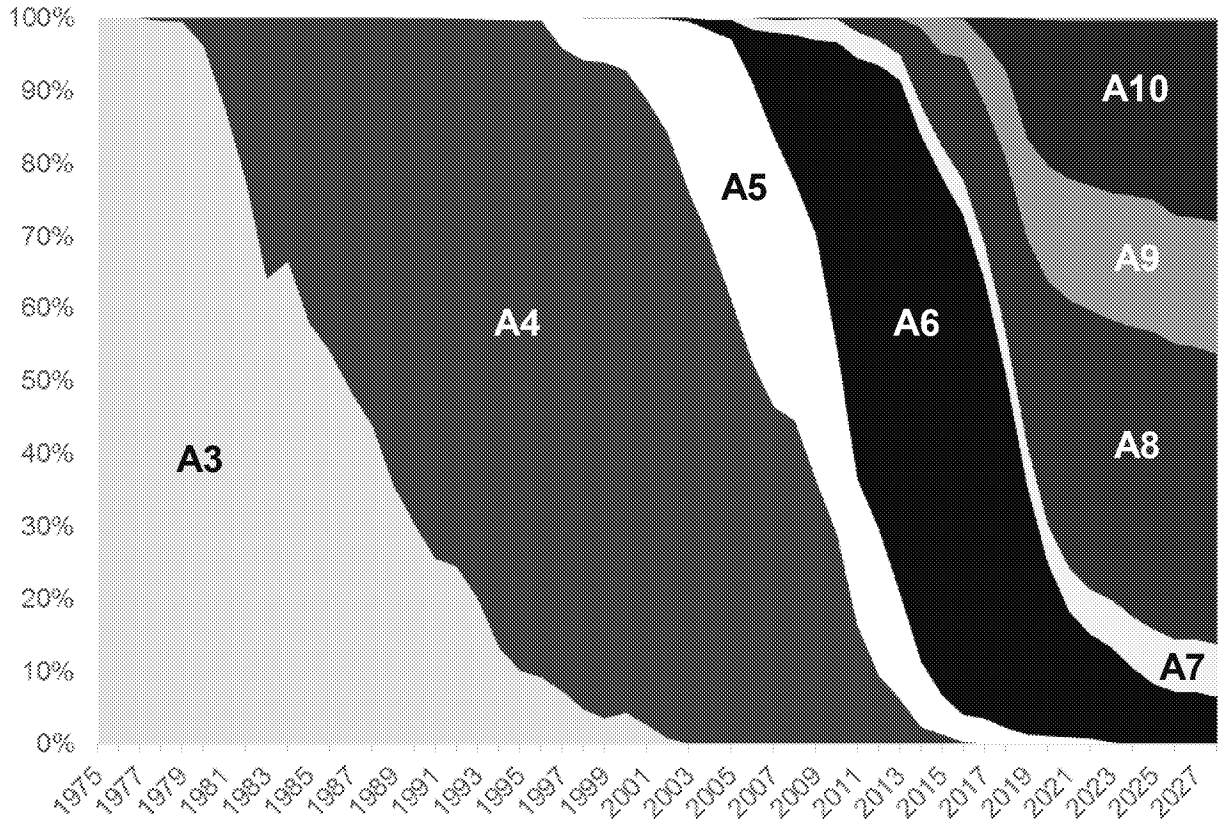
Consumers are flocking to longer loan terms to offset their monthly cost of ownership

Consumers who do not purchase the vehicle can see lower monthly payments via leasing as well

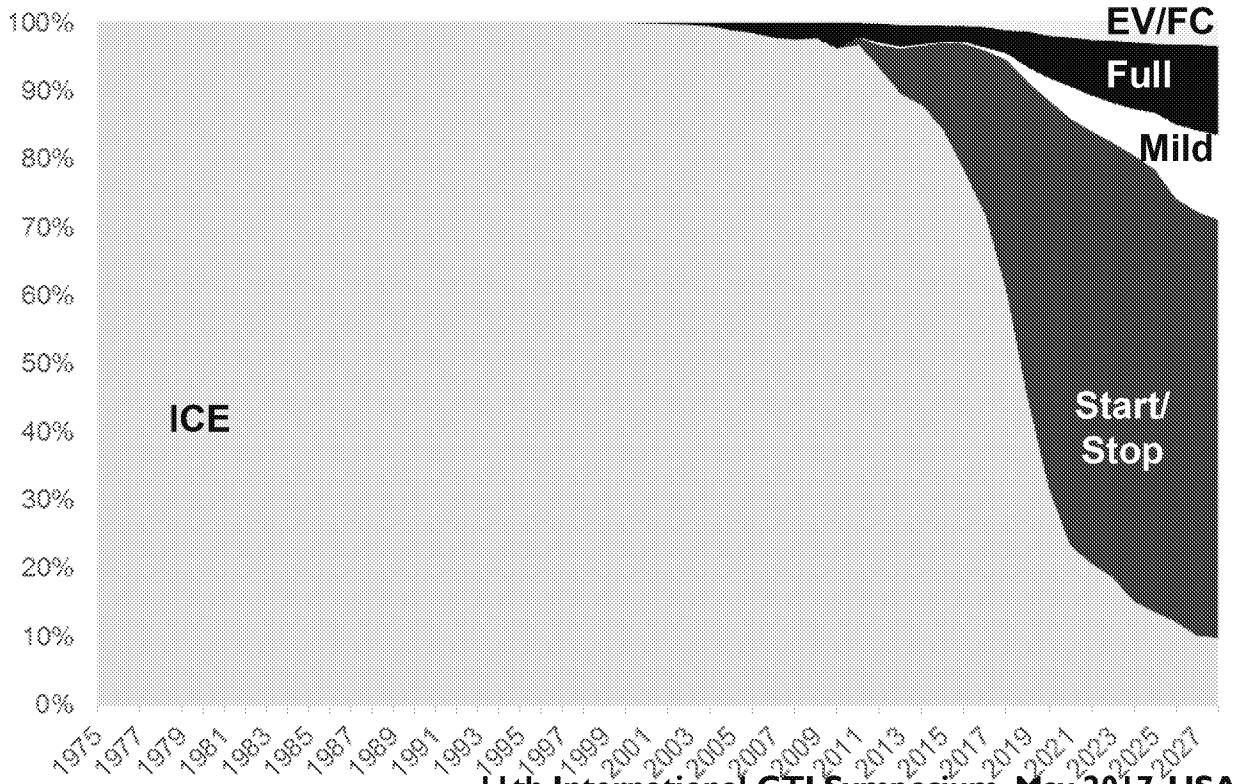
Sources: Federal Reserve Bank, IHS Markit

...but what impact has there been to automatic transmission design?

- 3 and 4 speed automatics dominant for 30 years
- Rapid design cycle changes over the last 10 years to support CAFE/GHG regulations
- 8, 9 and 10 speed designs to proliferate and dominate over the next 10 years.



Vehicle electrification levels are also undergoing significant change.



- The internal combustion engine was all the US market consumed until the first hybrid (Prius) in 2000.
- Step change in market adoption with Start/Stop functionality: Improved AT designs needed!
- EV's and Fuel Cells are not expected to proliferate.

Current U.S. Compliance & Compliance Forecast

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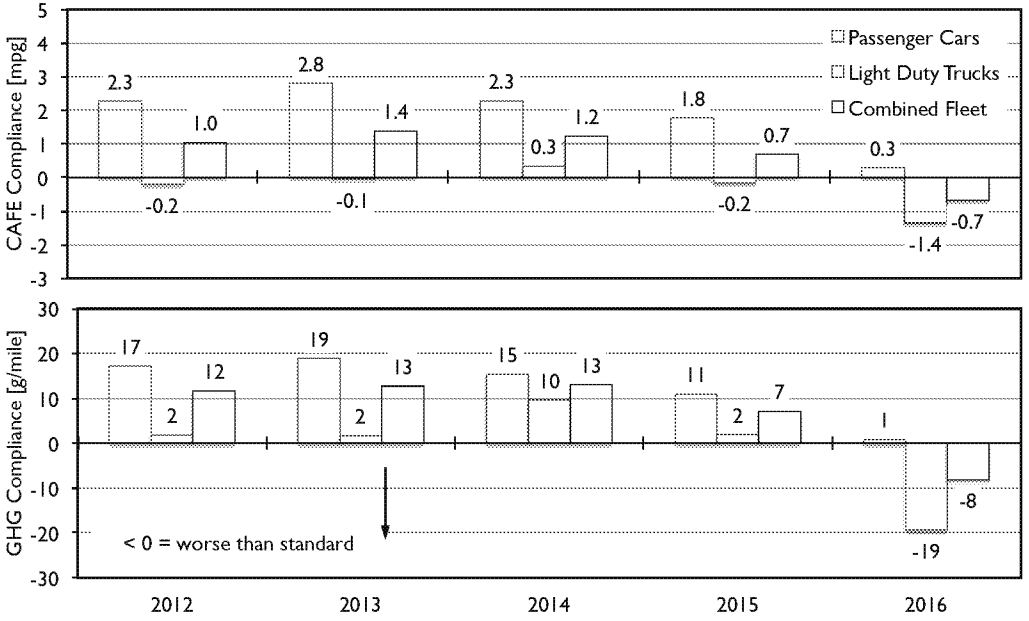
- Greg Pannone, President, Novation Analytics -

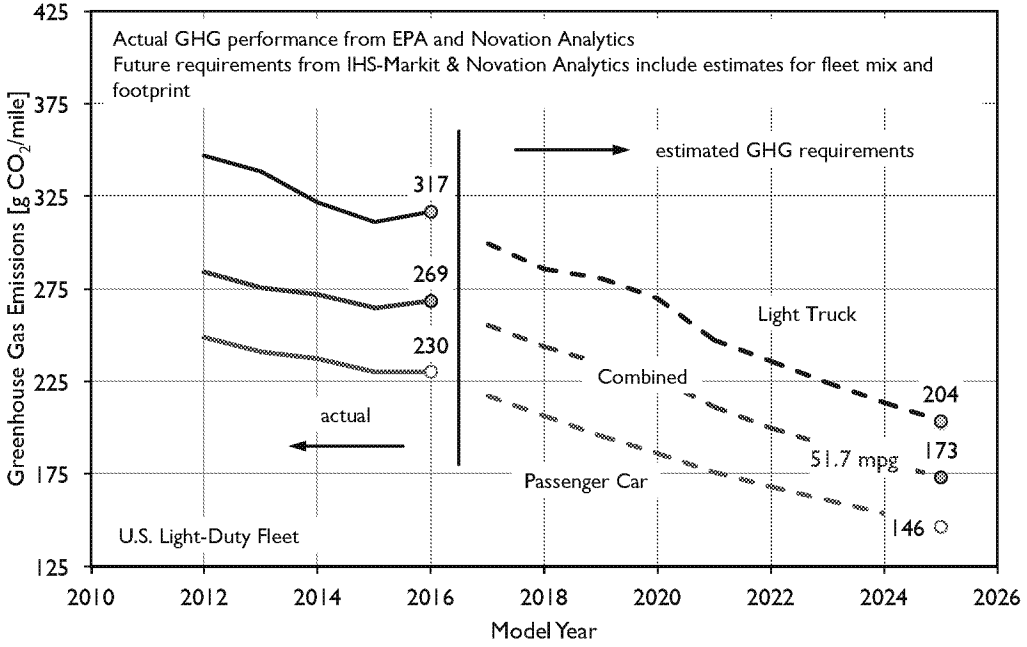
MYs 2012-2016 Performance

Model Year (MY) 2016 is projected to be the first year, since the latest rule-making was implemented, that the U.S. combined fleet Corporate Average Fuel Economy (CAFE) and Greenhouse Gas (GHG) standards will not be achieved based on the performance of the MY 2016 fleet alone. Carry-forward, carry-back credits will be required for compliance.



GHG Future Standards

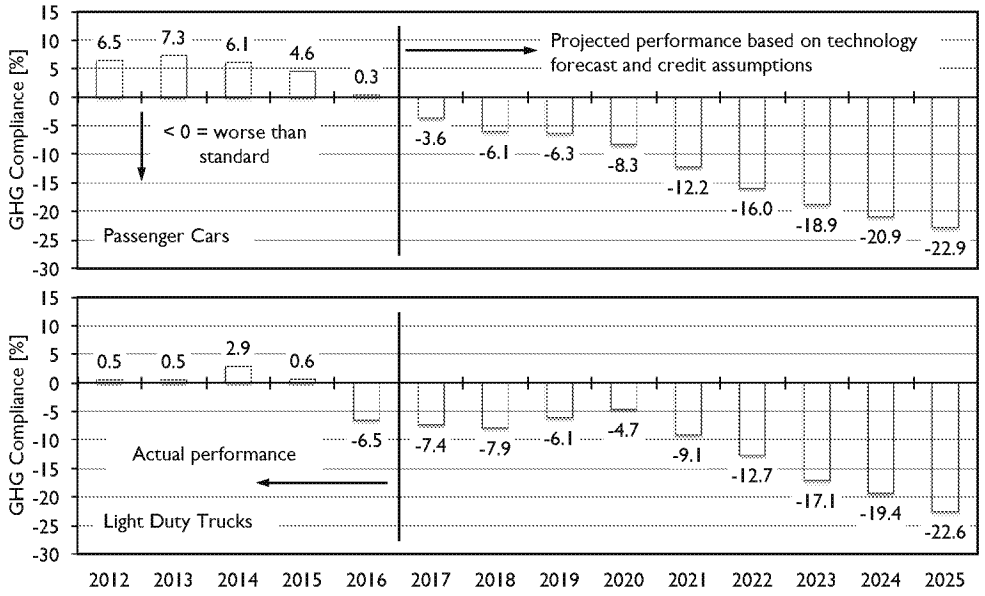
- The GHG performance for the MY 2016 U.S. light duty fleet is estimated to be 269 g CO2/mile versus a 260 g CO2/mile standard.
- Assuming changes to fleet mix and footprint, the combined fleet GHG standard is projected to drop to 173 g CO2/mile (51.7 mpg) for MY 2025, 33% lower than the MY 2016 performance.



Sources: MYs 2012-2015, EPA; MY 2016 Novation Analytics, for the Alliance of Automobile Manufacturers and the Association of Global Automakers (MY 2016 Baseline Study, December 20, 2016); MYs 2017-2025, IHS-Markit and Novation Analytics

GHG Performance

- Until MY 2016 the GHG performance for the U.S. light duty fleet has over performed relative to the standards.
- Given current technology and credit forecasts, the MY 2025 U.S. light-duty fleet is projected to under perform the GHG standards by 23% (33 g CO2/mile for passenger cars and 46 g CO2/mile for light trucks).



Sources: MYs 2012-2015, NHTSA; MY 2016 Novation Analytics, for the Alliance of Automobile Manufacturers and the Association of Global Automakers (MY 2016 Baseline Study, December 20, 2016); MYs 2017-2025, IHS-Markit and Novation Analytics

Technology Requirements for U.S. MY 2025 Compliance

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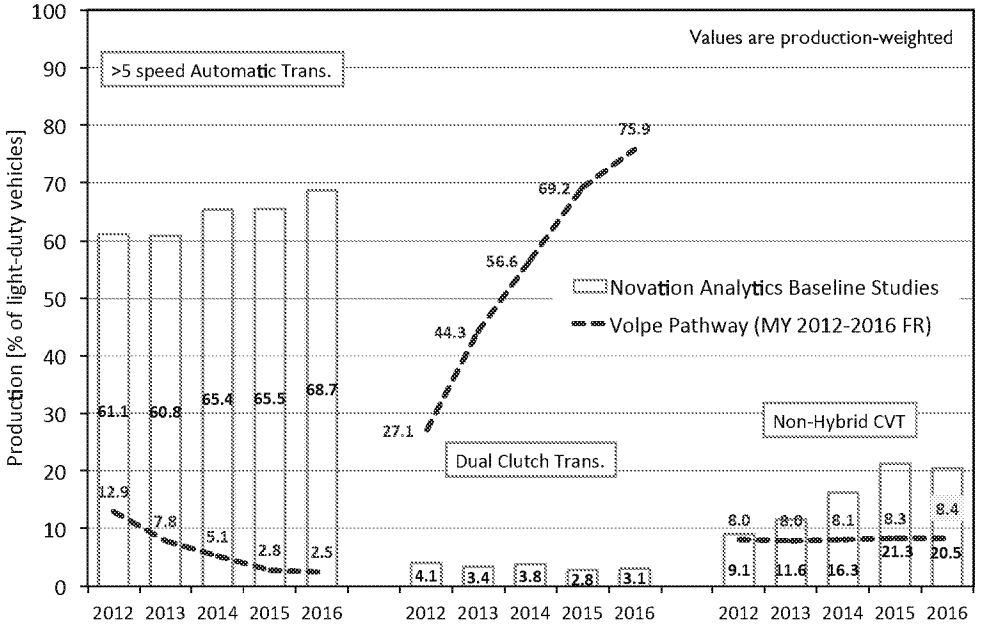
Agency Transmission Assumptions | MYs 2012 to 2016

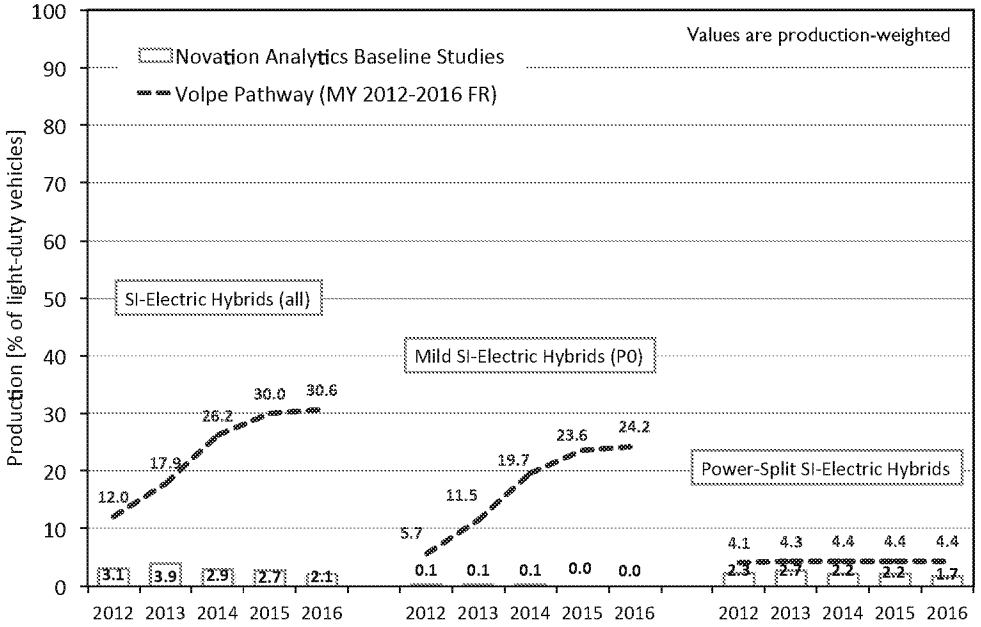
- The first phase of the U.S. final rulemaking (MYs 2012-2016) were based on technology pathway assumptions.
- The assumptions for transmission technology are shown (red lines) against the actual fleet deployment (orange bars).
- DCTs didn't dominate the market as assumed, rather OEMs focused on automatics and CVTs.



Sources: NHTSA; MY 2016 Novation Analytics, for the Alliance of Automobile Manufacturers and the Association of Global Automakers (MY 2016 Baseline Study, December 20, 2016); MYs 2017-2025, IHS-Markit and Novation Analytics

Agency Hybrid Assumptions | MYs 2012 to 2016

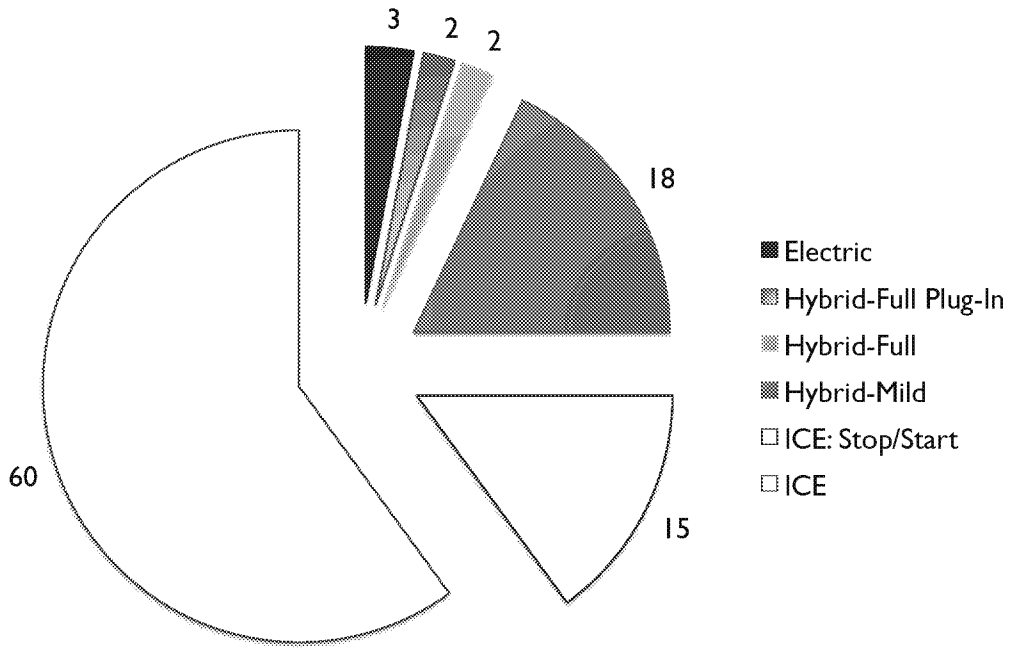
- The assumptions for hybrid technology are shown (red lines) against the actual fleet deployment (orange bars).
- Mild hybrids didn't increase in market share as assumed, rather OEMs focused on other fuel efficient technologies.



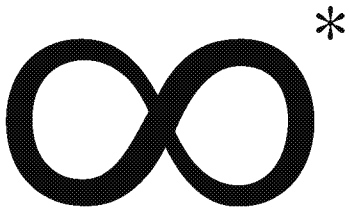
Sources: NHTSA; MY 2016 Novation Analytics, for the Alliance of Automobile Manufacturers and the Association of Global Automakers (MY 2016 Baseline Study, December 20, 2016); MYs 2017-2025, IHS-Markit and Novation Analytics

EPA's Technology Pathway to MY 2025

- Relative to the latest IHS-Markit forecast (which is not projected to comply), the EPA pathway included with the Proposed Determination has far less stop-start and roughly half the penetration of full and plug-in hybrids. However, mild hybrid share was approximately double the IHS forecast.



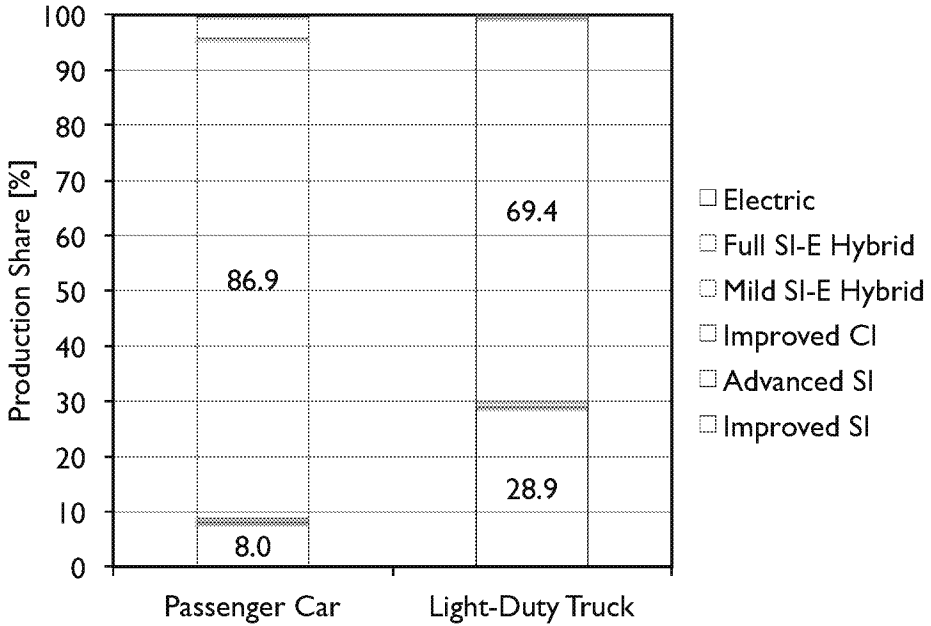
Number of Model Year 2025 Compliance Pathways



* Unconstrained by cost & consumer acceptance

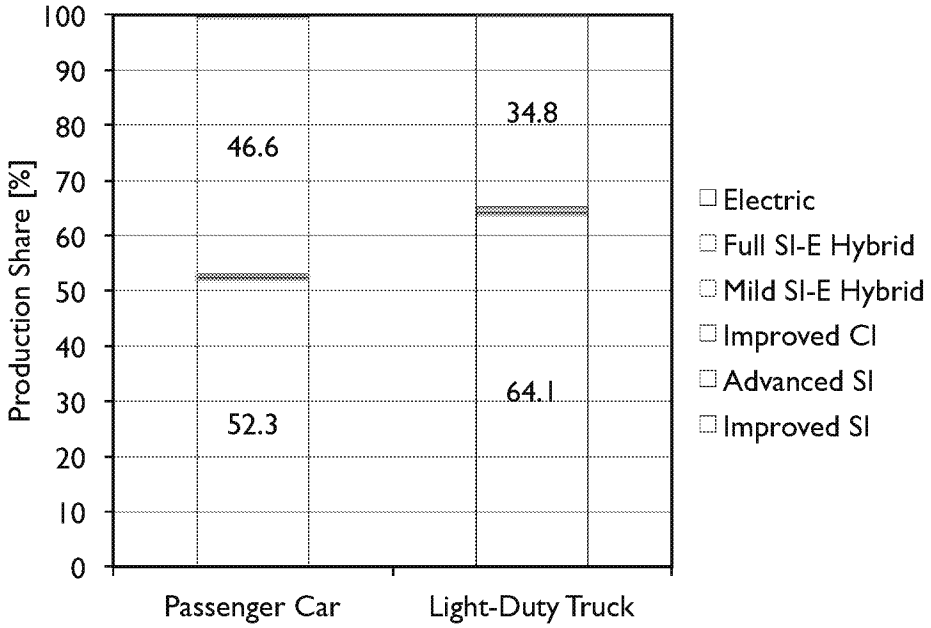
Model Year 2025 Compliance Pathway | Mild Hybrid Focused

- Scenario Assumptions:
  - CI, full hybrid, & electric deployments equal to MY 2016 but with improved efficiency for CI and full hybrid.
  - SI non-hybrid powertrains achieve a fleet average efficiency of 25% (current top 1%).
  - Improved efficiency mild hybrids are added until compliance is achieved.
- To achieve compliance with this scenario, approximately 75% of the fleet would require application of mild hybrids.



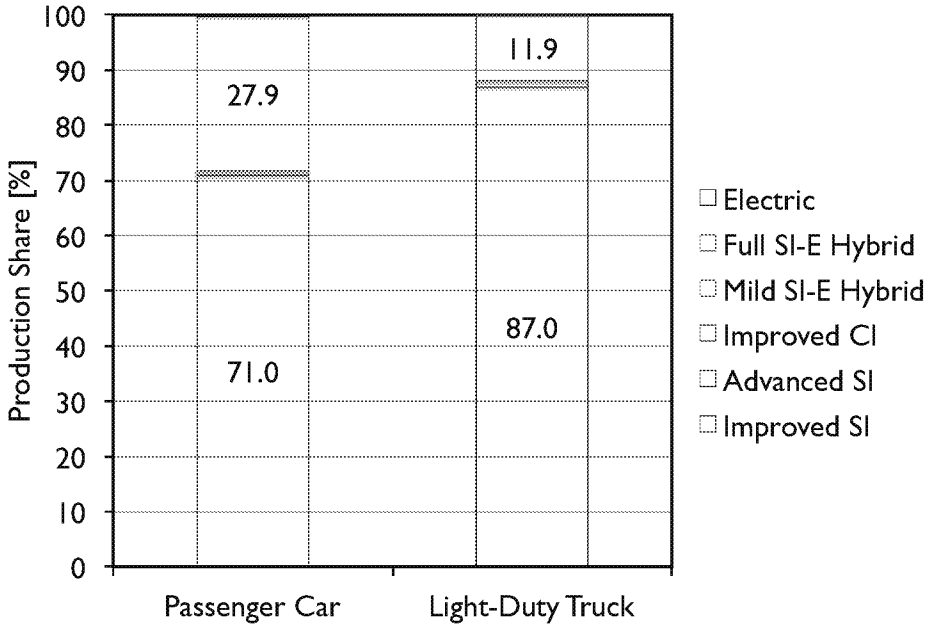
Model Year 2025 Compliance Pathway | Full Hybrid Focused

- Scenario Assumptions:
  - CI, mild hybrid, & electric deployments equal to MY 2016 but with improved efficiency for CI and mild hybrid.
  - SI non-hybrid powertrains achieve a fleet average efficiency of 25% (current top 1%).
  - Improved efficiency full hybrids are added until compliance is achieved.
- To achieve compliance with this scenario, approximately 40% of the fleet would require application of full hybrids.



Model Year 2025 Compliance Pathway | Advanced SI Focused

- Scenario Assumptions:
  - CI, mild hybrid, & electric deployments equal to MY 2016 but with improved efficiency for CI and mild hybrid.
  - SI non-hybrid powertrains achieve a fleet average efficiency of 28% (diesel-like efficiency).
  - Improved full hybrids are added until compliance is achieved.
- To achieve compliance with this scenario, approximately 20% of the fleet would require application of full hybrids.




Thank You
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